FACULTY OF SCIENCE

SOWETO SCIENCE CENTRE (SSC)

Teachers workshop

Subject: Physics – Linear Motion and General Physics Problems

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Tutorial Problem I

1. The speed of light is 300,000,000 m/s or 3 x 10^8 m/s. What is the speed in km/s and in km/hr?

2. What is the length of a light year, the distance light can travel in one year. Use 24 hours per day and 365.25 days per year.
   The distance to the nearest star is about 4.25 light years, the diameter of our galaxy is about 10^5 light years and the distance to the farthest visible galaxy is over 13 billion light years away.
   We live in a very big universe.

3. He is a problem in scaling that one can give learners as an example.
   The equatorial radius of the Earth is 6371 km. Imagine a string that circles the Earth at the equator. Nw make that string 4 metres longer. How far above the surface of the Earth will it be?

4. Here are three pairs of initial and final positions along the x axis. If displacement is defined as the Final Position MINUS the Initial Position, which of these pairs gives a negative displacement?

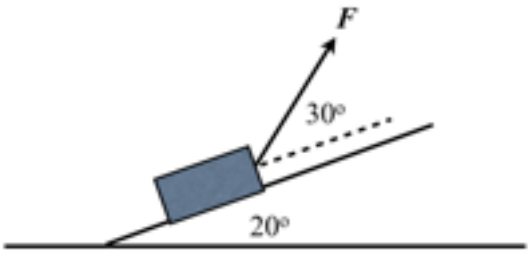
a) -3m, +5 m b) -3m, -7m c) 7m, -3m

5. The figure shows two horizontal forces moving a block along a frictionless floor. Assume that a third horizontal force F_3 also acts on the block. What are the magnitude and direction of F_3 when the block is a) stationary and b) moving left with a constant speed of 5 m/s?

6. A man is dragging a trunk up the loading ramp of a removals van. The ramp has a slope of 20 degrees and the man pulls on it with a force ***F*** whose direction is 30 degrees with respect to the ramp.

a) How large must the force F be so that the component of the force parallel to the ramp (which actually moves the trunk) be 60.0 N?

b) How large will the component perpendicular to the ramp be?



7. A 45.0 kg crate rests on a horizontal floor, You exert a gradually increasing horizontal push on it and you notice that the crate just starts to move when your force exceeds 313 N. After that, you reduce your force to 208N to keep it moving at a steady 25.0 cm/s.

a) What are the coefficients of static and kinetic friction between the crate and the floor?

b) What force would cause it to accelerate at 1.10 m/s^2?

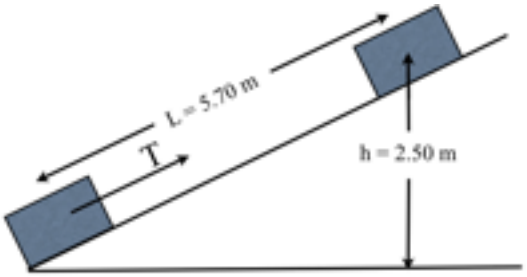
c) Repeat parts a) and b) if you were on the moon where the acceleration due to gravity is 1.62 m/s^2

Tutorial Problems II

1. a) Let us calculate the work done by the force *T*, which pulls the block of mass *m = 15 kg* up the ramp through some distance *L = 5.70* m, raising it above the floor by the distance *h =2.50* m above the ground. Ignore friction.

b) What is the work done, against gravity, if we were to lift the same block directly up through the distance *h*?

Notice that *T* is smaller than mg but that the work done is still the same.



2. A person pushed a *25.0 kg* block up a ramp at an angle of *25.0* degrees to the horizontal with a force of *209 N* parallel to the ramp. The crate slides *1.5* metres. If we ignore any possible friction between the block and the ramp, how much work work is done by a) the worker's force pushing the block, b) the weight of the block c) the Normal force exerted by the ramp on the block, and d) the total work done?

3. Now imagine this same system but with friction. Let the coefficient of static friction be *0.3* and the coefficient of kinetic friction be *0.2*.

a) What force would be needed to get the block moving from rest?

b) What force would be needed to keep the block moving at constant velocity once it begins to move?

c) If the force were the same as Problem 2, that is *209 N*, what would the acceleration of the block be?

4. A block is to be weighed in a lift inside a tall building. The mass is 4 kg. Calculate the weight when the lift is

a) stationary

b) accelerating upwards at 2.5 m/s^2

c) accelerating downwards at 3.o m/s^2

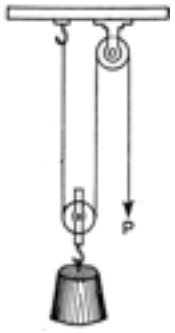
d) moving upwards at a constant velocity of 4.0 m/s

Tutorial Problems III

1. An object of 102 kg moves in a horizontal straight line with an initial speed of 53 m/s. It is stopped along that line by a deceleration of 2. 0 m/s^2
a) What is the magnitude of the force required?
b) What distance does it travel while decelerating?
c) What work is done by the force is stopping the answer?
d) Answer the same question is the deceleration was 4.0 m/s^2.

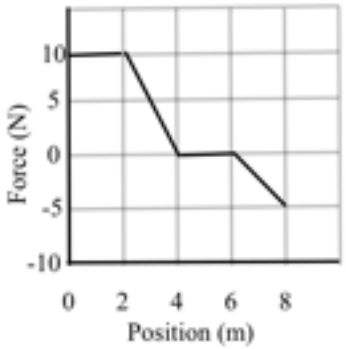
2. A worker pushes a 25.0 kg crate up a frictionless incline, angled at 25 degrees to the horizontal. A force of 209 N is exerted on the crate, parallel to the incline. The crate slides 1.5 metres.
a) How much work is done on the crate by the worker?
b) How much work is done by the weight of the crate?
c) How much work is done by the normal force exerted by the incline on the crate?
d) What is the total work done on the crate?

3. A mass of 20 kg hangs from this pulley system.



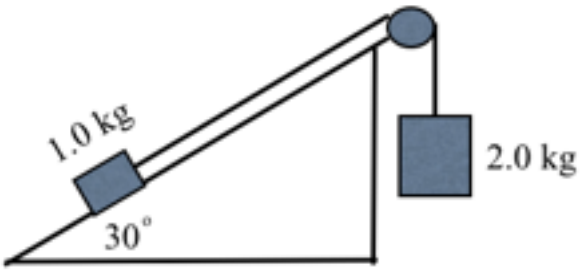
a) What must be the force ***P*** pulling on the rope if you are to lift the weight at a constant speed? (Hint: there are two ropes lifting the mass)
b) To lift the mass by 2.0 cm how far must you pull the free end of the rope?
During the lift, what work id done by
c) your force
d) the weight of the mass,
e) Is Energy conserved in this problem? Why?

4. A 5.0 kg block moves in a straight line on a horizontal frictionless surface under a force that varies with position as shown in the figure. How much work is done when the block moves from x = 0 to x = 8.0 metres?



5. You drop a 2.0 kg book from a window 10.0 metres above the ground. A friend catches the book 1.5 metres above the ground in her outstretched hands.
a) How much work is done on the book by its weight as it drops to your friend?
b) what is the change in gravitational potential energy during the drop? (Take the zero of PE to be at the ground)
c) What is its potential energy when you hold it 10 metres above the ground?
d) What is its potential energy when your friend catches it?
e) What is its velocity when caught?

6. The pulley is massless so turning it does not require work to turn it. The surface is frictionless. The masses are released from rest and the cord is always taut. What is the total Kinetic Energy of the two blocks when the 2.0 kg mass has fallen by 25 cm?



7. How many Joules of Energy does a 100 Watt light bulb use in 1 hour? How fast would a 70 kg person have to run to have that amount of Kinetic Energy?

8. A ski resort has a rope tow to pull riders to the top of the mountain. If the rope is 300 metres long, the hill has a slope of 15 degrees, and the tow has the power to pull 50 riders of average mass 70 kg, and the rope moves at 12 km/hr, how much power does this machine have? (Hint: For time, calculate the time it takes one rider to get from bottom to top, and multiply by the number of riders)

Tutorial Problems IV

1. On April 13, 2029 the asteroid 99942 Apophis will pass within approximately 30,000 km of Earth. This is only 6% of the distance to the Moon, so it is relatively close. It has a density of 2600 kg/m^3 and is approximately a sphere of 320 metres in diameter. It will be travelling at a speed of about 12.6 km/s.

a) If it were slightly deflected in its orbit and struck the Earth, how much Kinetic Energy would it have?

b) The largest nuclear weapon ever created on Earth (but not detonated) 2 x 10^{17} Joules? Would the asteroid strike be a larger amount of energy than this?

2. A pump lifts 800 kg of water per minute from a well that is 14.0 metres deep and it ejects the water with a speed of 18.0 m/s

a) How much work is done per minute in lifting the water?

b) How much work is done in giving the water the Kinetic Energy it has when ejected.

c) What must be the Power output of the pump?

3. The human heart is a very reliable and very powerful pump. Each day it moves about 7500 Litres of blood. If the distance it moves the blood is, for an approximation, the average height of a human, say 1.6 metres, and the density of blood is 1.05 x 10^3 kg/m^3, then

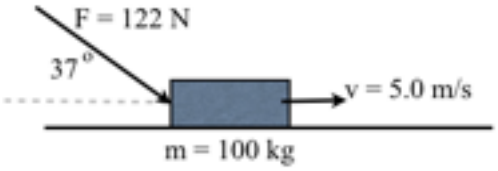
a) how much work does the heart do in a day?

b) what is the heart's Power output?

(1 m3 = 1000 Litres)

4. The cab of a lift has a mass of 3000 kg and moves 210 metres up the shaft in 23 seconds at constant speed. How much work is done? What is the power needed to pull the lift up?

5. In this drawing, what is the power exerted by this force?



6. An initially stationary 2.0 kg object accelerates uniformly and horizontally to a speed of 10 m/s in 3.0 seconds.

a) In that 3.0 s interval, how much work is done on the object by the force accelerating it?

b) What is the power input at the end of this interval (at 3.0 s)?

c) What is the power input at the end of the first half of the interval (1.5 s)

Hint: Calculate the Force necessary and then make a graph of Force versus time.

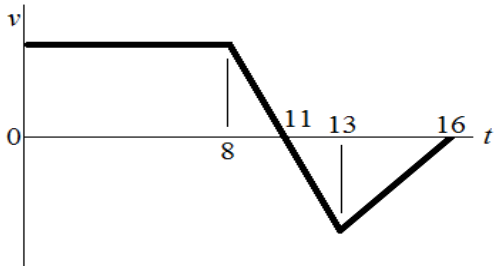
Additional Challenge Problems

1 The table below shows the results of a ticker timer experiment. Calculate the acceleration

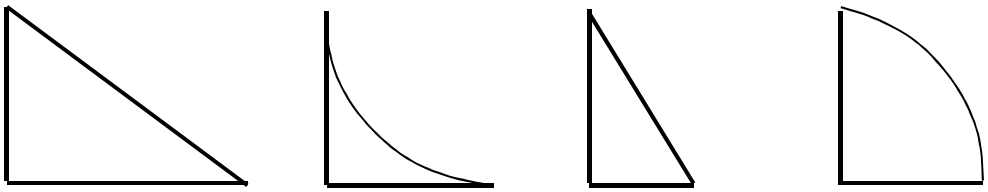
Section of Tape	Time at Start (s)	Time Interval (s)	Length of section (cm)
1	0.0	0.1	5.3
2	0.1	0.1	9.9
3	0.2	0.1	14.5

2 In which of the following intervals is the object speeding up in the graph below?

A 0 s - 8 s
B 0 s - 11 s
C 8 s - 11 s
D 8 s - 13 s
E 11 s - 13 s
F 13 s - 16 s



3 On which of the following hills does the ball roll down with increasing speed and decreasing acceleration?



A B C D

4 A ball rolls at a constant velocity u, a distance D along a horizontal table top of height H and then rolls off the top and falls to the floor. It bounces up reaches a height h < H falls down into a puddle of syrup and sticks to the ground.

Draw the following graphs:
1 Velocity – Time
2 Speed – Time
3 Then discuss the distance – time and velocity – time graphs.

5 The balls roll down the two slopes below. They start at A at the same time and end at F. Which ball gets to F first, the one on slope X, (AF) or the one on slope Y (ABCDEF) ? Also draw the V-T graphs for both.